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# Module 12

## Channel Adequacy and Ditch Computations

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# Plan review involves verification of channel adequacy

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# Channel Analysis:

- Channel geometry - three cross sections 50’ apart from discharge point.
- Channel lining
- Channel slope
- Energy slope - hydraulic grade line calculation of the existing or proposed pipe system

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# Channel Analysis (cont.):

- Applicant should investigate channel
  - to verify cross sections provided accurately depict channel, and
  - that there are no significant restrictions downstream

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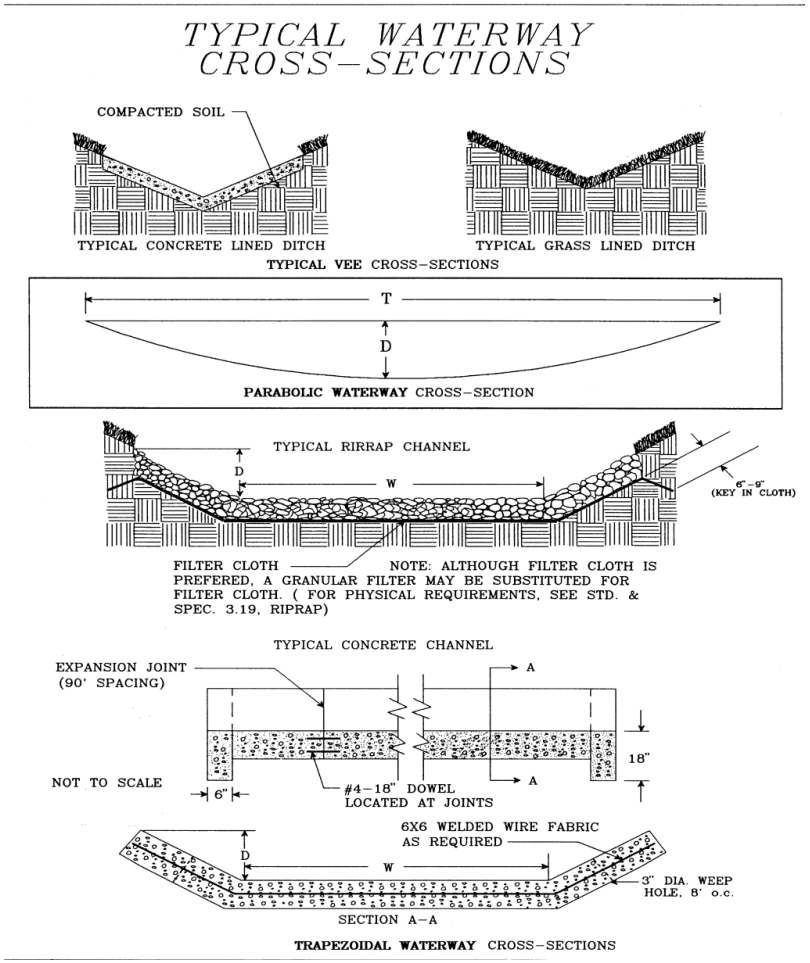
# Stormwater Conveyance Channel-3.17



# Reviewing Channel Design

- Top width of parabolic and v-shaped channels not to exceed 30’
- Bottom width of trapezoid and grass lined not to exceed 15’
- Outlet protection
- Grass lined channels stabilized by the permanent seeding and/or sod specification
- Erosion netting
- Riprap use Std & Specs

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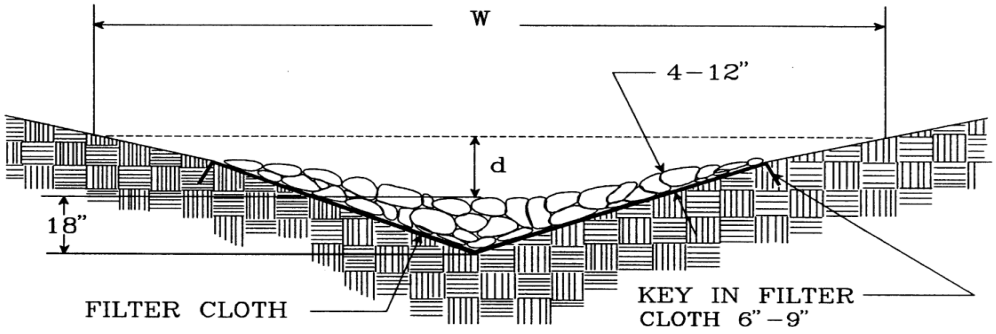
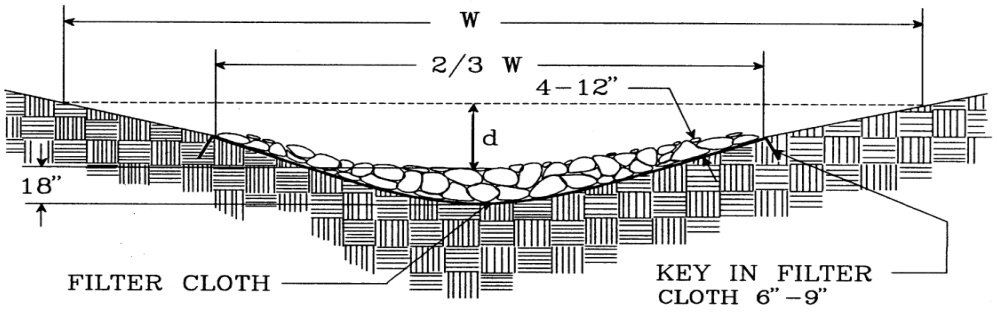
# STONE–LINED WATERWAYS




V–SHAPED WATERWAY WITH STONE CENTER DRAIN

NOTE: A GRANULAR FILTER MAY BE SUBSTITUTED FOR FILTER CLOTH.




PARABOLIC WATERWAY WITH STONE CENTER DRAIN

NOTE: A GRANULAR FILTER MAY BE SUBSTITUTED FOR FILTER CLOTH.

# Concrete lined channels

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# Open Channel Flow: MS-19 and VSMP Regs Part IIB

- Man-made
  - *Capacity – 10-year storm*
  - *Stability – 2-year storm*
- Natural
  - *Energy Balance – 1-year storm*
- Storm Sewer Systems - *Capacity for 10-year storm*

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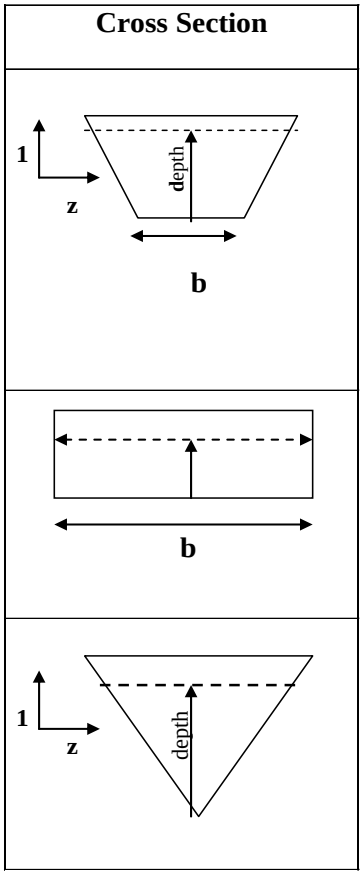
# Channel Analysis: MS-19

- Channel capacity
  - Based on channel geometry and lining (roughness)
  - Compare to drainage area and design storm

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# Channel Analysis: MS-19

- Channel lining
  - - Permissible velocity of lining compared to velocity of design storm
  - - Permissible velocities (VESCH Table 5-14, p. V–120) or in manufacturer's specifications

| Channel Slope | Lining | Velocity* (ft./sec.) |
|---|---|---|
| 0 - 5% | Bermudagrass | 6 |
| | Reed canarygrass<br>Tall fescue<br>Kentucky bluegrass | 5 |
| | Grass-legume mixture | 4 |
| | Red fescue<br>Redtop<br>Sericea lespedeza<br>Annual lespedeza<br>Small grains<br>Temporary vegetation | 2.5 |
| 5 - 10% | Bermudagrass | 5 |
| | Reed canarygrass<br>Tall fescue<br>Kentucky bluegrass | 4 |
| | Grass-legume mixture | 3 |
| Greater than 10% | Bermudagrass | 4 |
| | Reed canarygrass<br>Tall fescue<br>Kentucky bluegrass | 3 |
| * For highly erodible soils, decrease permissible velocities by 25%. | | |

# Manning's Equation

$$V = \frac{1.49}{n} \times R^{(2/3)} \times \sqrt{s}$$

**V = velocity (fps)**

**n = Manning's roughness coefficient (dimensionless)**

**R = hydraulic radius (A/P)**

A= wetted cross sectional area

P=wetted perimeter(ft)

**s = slope (in ft/ft - NOT percent slope)**

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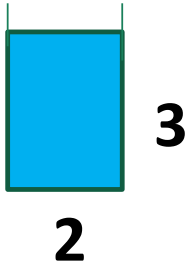
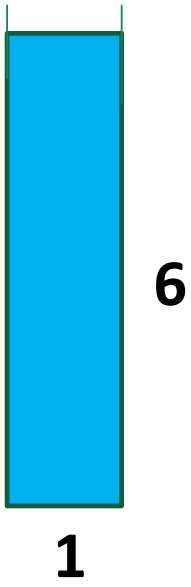
# Hydraulic radius




A = 2x3 = 6

P = 3+2+3 = 8

R = A/P = 6/8 = 0.75




A = 1x6 = 6

P = 6+1+6 = 13

R = A/P = 6/13 = 0.46

# Open Channel Flow: Roughness Coefficients - Manning's (n)

| | |
|---|---|
| Concrete Pipe | .012 to .016 |
| Earthen Ditch | .017 to .025 |
| Canal w/ stone bed & weeds on bank | .025 to .04 |
| Earth bottom & rubble sides | .028 to .035 |

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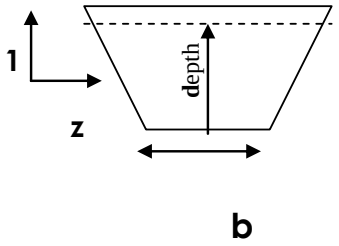
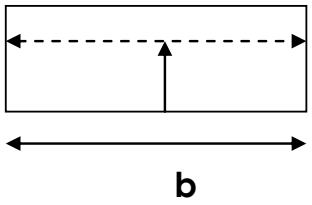
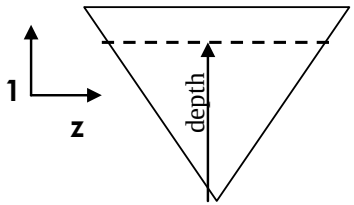
**TABLE 5-8**

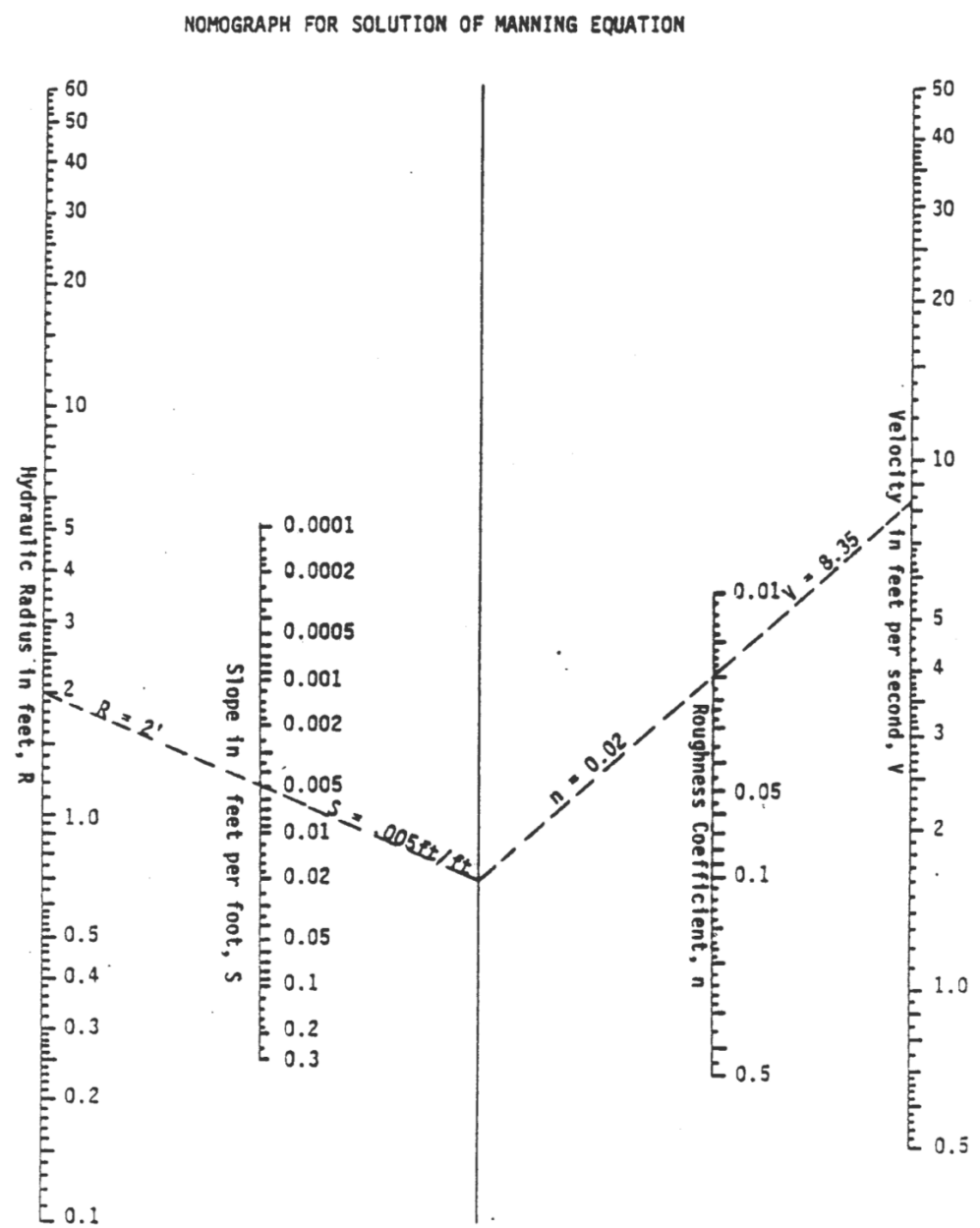
**MANNING'S "n" VALUES**

| Surface | Best | Good | Fair | Bad |
|---|---|---|---|---|
| Uncoated cast-iron pipe | 0.012 | 0.013 | 0.014 | 0.015 |
| Coated cast-iron pipe | 0.011 | 0.012* | 0.013* | |
| Commercial wrought-iron pipe, black | 0.012 | 0.013 | 0.014 | 0.015 |
| Commercial wrought-iron pipe, galvanized | 0.013 | 0.014 | 0.015 | 0.017 |
| Riveted and spiral steel pipe | 0.013 | 0.015* | 0.017* | |
| Common clay drainage tile | 0.011 | 0.012* | 0.014* | 0.017 |
| Neat cement surfaces | 0.010 | 0.011 | 0.012 | 0.013 |
| Cement mortar surfaces | 0.011 | 0.012 | 0.013* | 0.015 |
| Concrete pipe | 0.012 | 0.013 | 0.015* | 0.016 |
| Concrete-lined channels | 0.012 | 0.014* | 0.016* | 0.018 |
| Cement-rubble surface | 0.017 | 0.020 | 0.025 | 0.030 |
| Dry-rubble surface | 0.025 | 0.030 | 0.033 | 0.035 |
| Canals and ditches: | | | | |
| Earth, straight and uniform | 0.017 | 0.020 | 0.0225* | 0.025 |
| Rock cuts, smooth and uniform | 0.025 | 0.030 | 0.033 | 0.035 |
| Rock cuts, jagged and irregular | 0.035 | 0.040 | 0.045 | |
| Winding sluggish canals | 0.0225 | 0.025* | 0.0275 | 0.030 |
| Dredged earth channels | 0.025 | 0.0275* | 0.030 | 0.033 |
| Canals with rough stony beds, weeds on earth banks | 0.025 | 0.030 | 0.035* | 0.040 |
| Earth bottom, rubble sides | 0.028 | 0.030* | 0.033* | 0.035 |

* Values commonly used in designing.

# Open Channel Flow-Geometry

| Section | Area<br>a | Wetted Perimeter<br>P | Hydraulic Radius<br>R = a/P | Top Width<br>T |
|---|---|---|---|---|
|  | $bd + zd^2$ | $b + 2d(z^2+1)^{1/2}$ | $\frac{bd + zd^2}{b + 2d(z^2+1)^{1/2}}$ | $b + 2zd$ |
|  | $bd$ | $b + 2d$ | $\frac{bd}{b + 2d}$ | $b$ |
|  | $zd^2$ | $2d(z^2+1)^{1/2}$ | $\frac{zd^2}{2d(z^2+1)^{1/2}}$ | $2zd$ |

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# Continuity Equation

$$Q = V * A$$

Q = discharge (cfs)

V = velocity (from Manning's, fps)

A = Cross sectional area ($ft^2$)

cfs = fps * $ft^2$

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# Open Channel Flow

## Manning Equation

$V = (1.49/n) * (R^{2/3}) * (S^{1/2})$

## Continuity Equation

$Q = V * A$

*by substitution:*

## Discharge Equation

$Q = (1.49/n) * S^{1/2} * R^{2/3} * A$

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